ORBIT PREDICTIONS USING KS ELEMENTS WITH EARTH'S FLATTENING

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Abstract

Predicting the orbit of a satellite is a fundamental requirement in many areas of aerospace, such as mission planning, satellite geodesy, re-entry prediction, maneuver planning, collision avoidance, formation flying, etc. For near-Earth orbits, the forces due to the non spherical nature of the Earth and atmospheric drag plays an important role and are mainly responsible to bring the satellite back to the Earth. Thus inclusion of the effect of these perturbing forces becomes important for precise orbit computation of near-Earth orbits. Many transformations have emerged in the literature to stabilize the equations of motion either to reduce the accumulation of local numerical errors or allowing the use of large integration step sizes, or both in the transformed space. One such transformation is known as KS transformation by Kustaanheimo and Stiefel [1], who regularized the nonlinear Kepler equation of motion and reduced it into linear differential equations of a harmonic oscillator of constant frequency. In this paper a detailed analysis is carried out for orbit prediction using KS differential equations by including the non spherical gravitational potential of the Earth as the perturbing force. Earths zonal and tesseral harmonics, which produce bands of constant deviation from the spherical field along lines of latitude and longitude, are included to precisely model the Earth's gravitational potential. Higher order Earth's flattening terms are included by utilizing the recurrence relations of associated Legendre polynomial and its derivatives. To know the effectiveness of the theory, the results are compared with the real IRS-1A satellite data and the results of other existing solutions for a long duration of nearly a month time. The comparison shows that the KS method provides one of the most and accurate techniques for orbit prediction available at present.

Keywords: Orbit prediction; Earth's flattening; Semi-major axis; Eccentricity; KS elements